Distribution Planning with DER: Distribution System-Wide Impact Assessment Methods

Jeff Smith, Manager,
Power System Studies

Matthew Rylander, Technical Leader
Power System Studies

EPRI

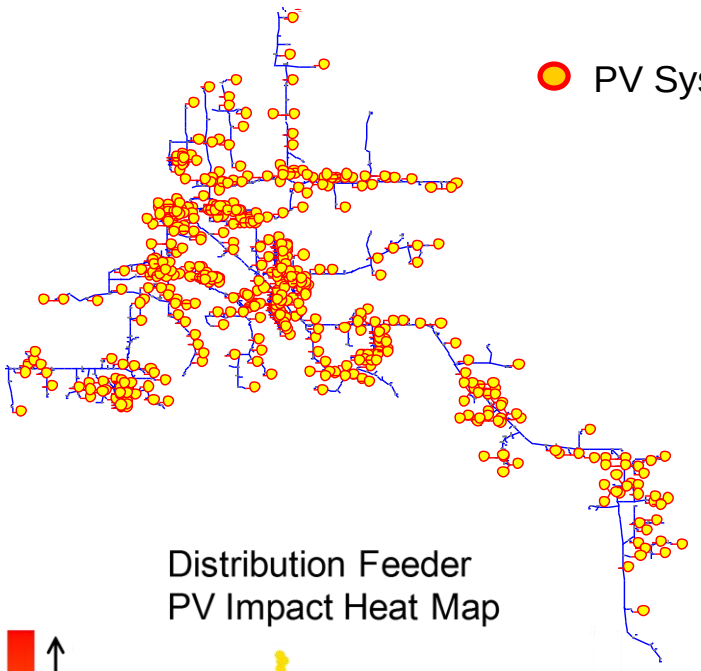
Integrating PV in Distribution Grids:
Solutions and Technologies Workshop

NREL ESIF
October 22, 2015
Golden, Colorado

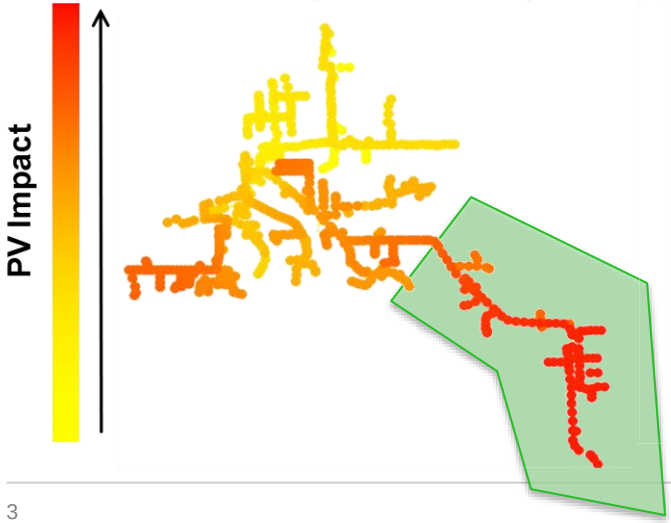
Evolving Planning Tools

- Vendor tools advance at the rate their customers require additional functionality
  - Sequential time-series analysis
- Open-Source tools like OpenDSS advance more quickly as needed for research
  - Smart inverter controls
  - System-wide planning (Distribution Resource Plans)
  - Distribution System Management (DMS) applications

System-wide began years ago…
Detailed Feeder Hosting Capacity



Distribution Feeder
PV Impact Heat Map



- Baseline – No PV
- PV Penetration 1
- PV Penetration 2
- PV Penetration 3
- Beyond…

Process is repeated 100's of times to capture many possible scenarios

Increase Penetration Levels Until Violations Occur

- voltage
- protection
- power quality
- thermal

Detailed Analysis led to…

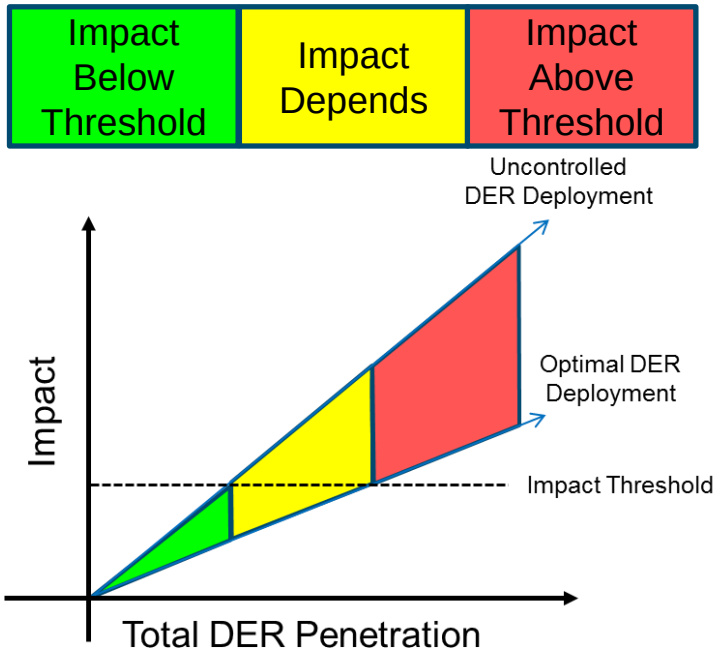
What matters most?

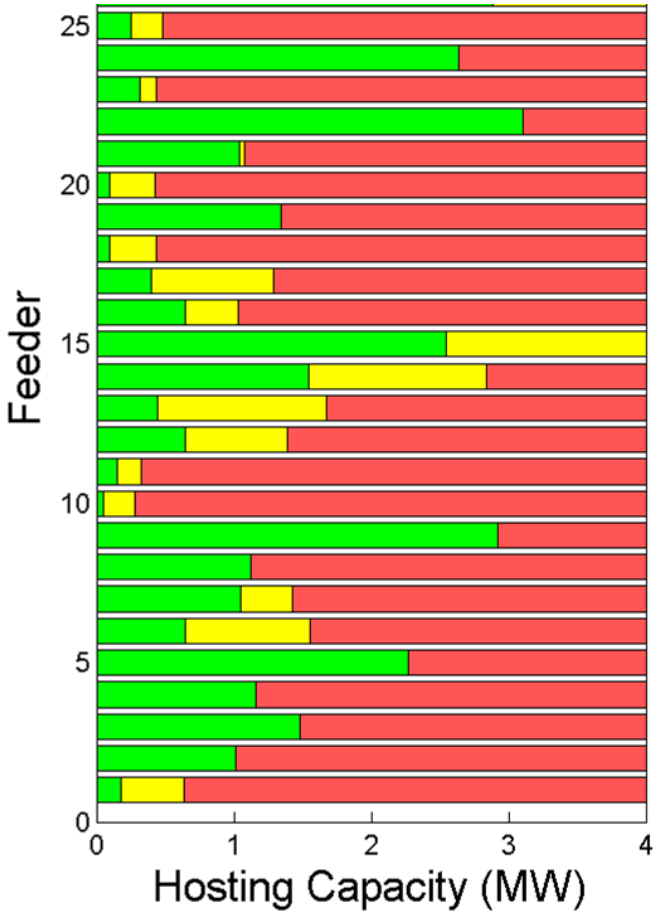
- DER technology and impacts
- DER size and location
- Feeder design and operation

Voltage

Protection coordination

Thermal capacity





DER Technology and Impacts

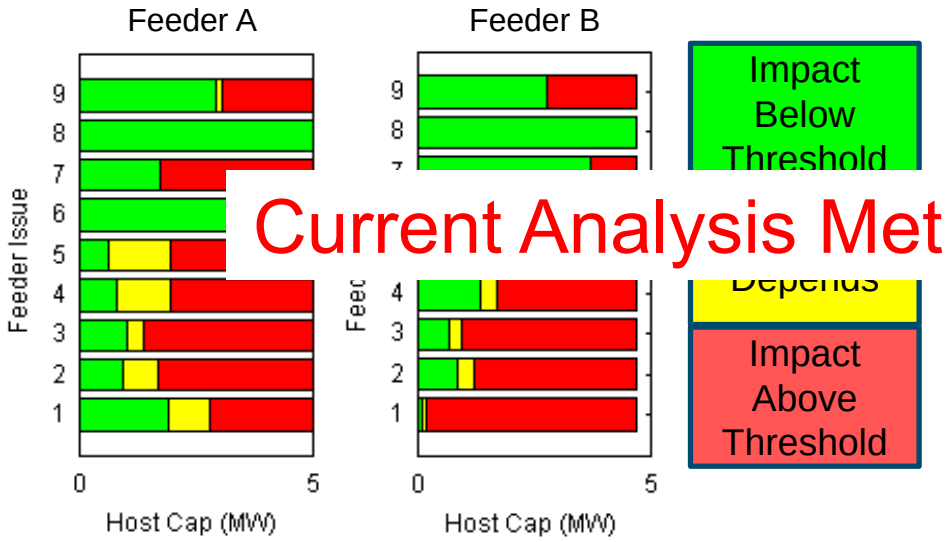
DER Size and Location

Feeder Design and Operation

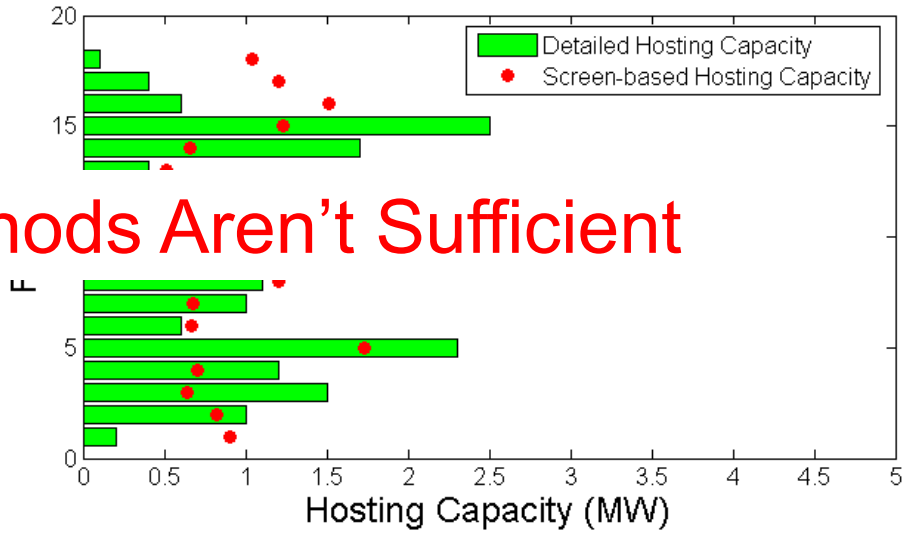
The Question Arose… How to Analyze System-Wide?

- Detailed system analysis requires significant time/resources
- "Work-arounds" have included:
  - Detailed analysis on select feeders and extrapolating results to others
  - Simplified screening analysis on all feeders

Extrapolation Problem:
Two similar feeders with different results



Screening Problem:
Under and over conservative results



Current Analysis Methods Aren't Sufficient

To go System-wide, New Methods are Needed

- Captures what matters most
  - DER technology and impacts
  - DER size and location
  - Feeder design and operation

EPRI's Streamlined Hosting Capacity Method

Key Components of an Effective Method

Granular	• Capture unique feeder-specific responses
Repeatable	• As distribution feeders change
Scalable	• System-wide assessment
Transparent	• Clear and open methods for analysis
Proven	• Validated techniques
Available	• Utilize readily available utility data and tools

Streamlined Hosting Capacity Method – What is it?

Input

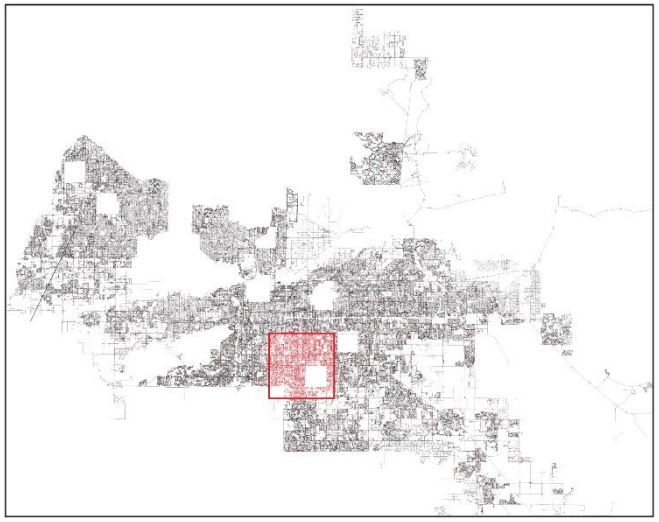
- Database of feeders from distribution planning software (CYME, Milsoft, Synergi)

The Method

- Developed from years of detailed hosting capacity analysis
- Works within existing planning tools
- Considers voltage, thermal, and protection impacts
- Considers DER technology impacts
- Considers DER size and location

Output

- Effectively and efficiently analyzes each and every feeder in system
- Provides Node-level, feeder-level, and system-level hosting capacity
- Issues found at X penetration
- Locations where DER is more/less likely to cause grid issues



Database of existing distribution feeder planning models

Details on Streamlined Method: EPRI Report 3002003278, 2015

Streamlined Hosting Capacity Method – What is it?

Input

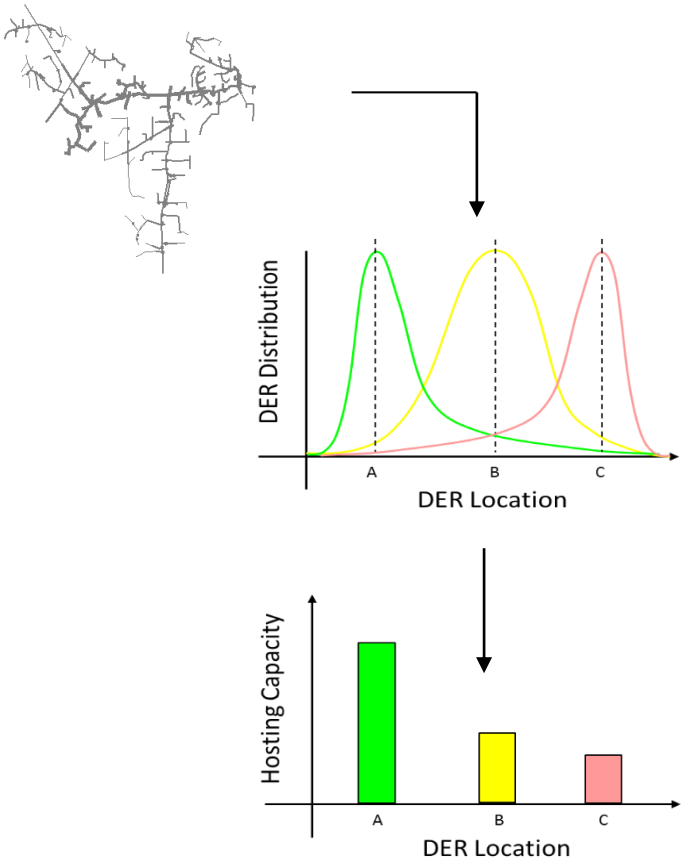
- Database of feeders from distribution planning software (CYME, Milsoft, Synergi)

The Method

- Developed from years of detailed hosting capacity analysis
- Works within existing planning tools
- Considers voltage, thermal, and protection impacts
- Considers DER technology impacts
- Considers DER size and location

Output

- Effectively and efficiently analyzes each and every feeder in system
- Provides Node-level, feeder-level, and system-level hosting capacity
- Issues found at X penetration
- Locations where DER is more/less likely to cause grid issues



On Feeder-by-feeder, step ranges of distribution locations to determine ranges of hosting capacity

Details on Streamlined Method: EPRI Report 3002003278, 2015

Streamlined Hosting Capacity Method – What is it?

Input

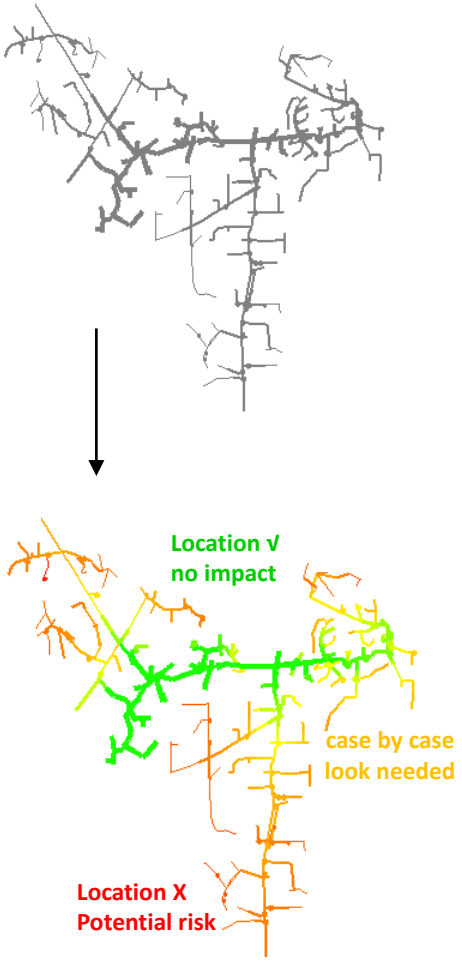
- Database of feeders from distribution planning software (CYME, Milsoft, Synergi)

The Method

- Developed from years of detailed hosting capacity analysis
- Works within existing planning tools
- Considers voltage, thermal, and protection impacts
- Considers DER technology impacts
- Considers DER size and location

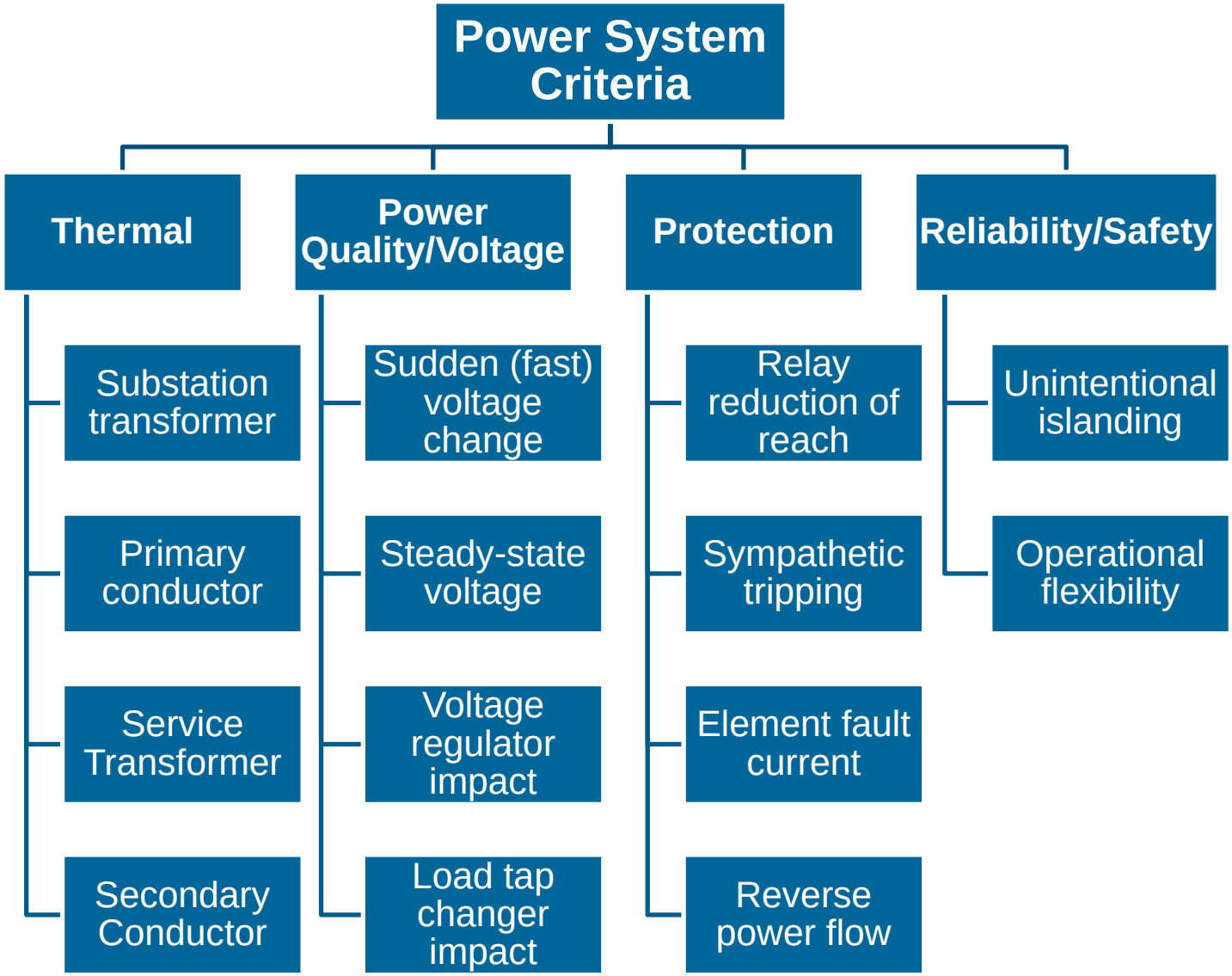
Output

- Effectively and efficiently analyzes each and every feeder in system
- Provides Node-level, feeder-level, and system-level hosting capacity
- Issues found at X penetration
- Locations where DER is more/less likely to cause grid issues



Details on Streamlined Method: EPRI Report 3002003278, 2015

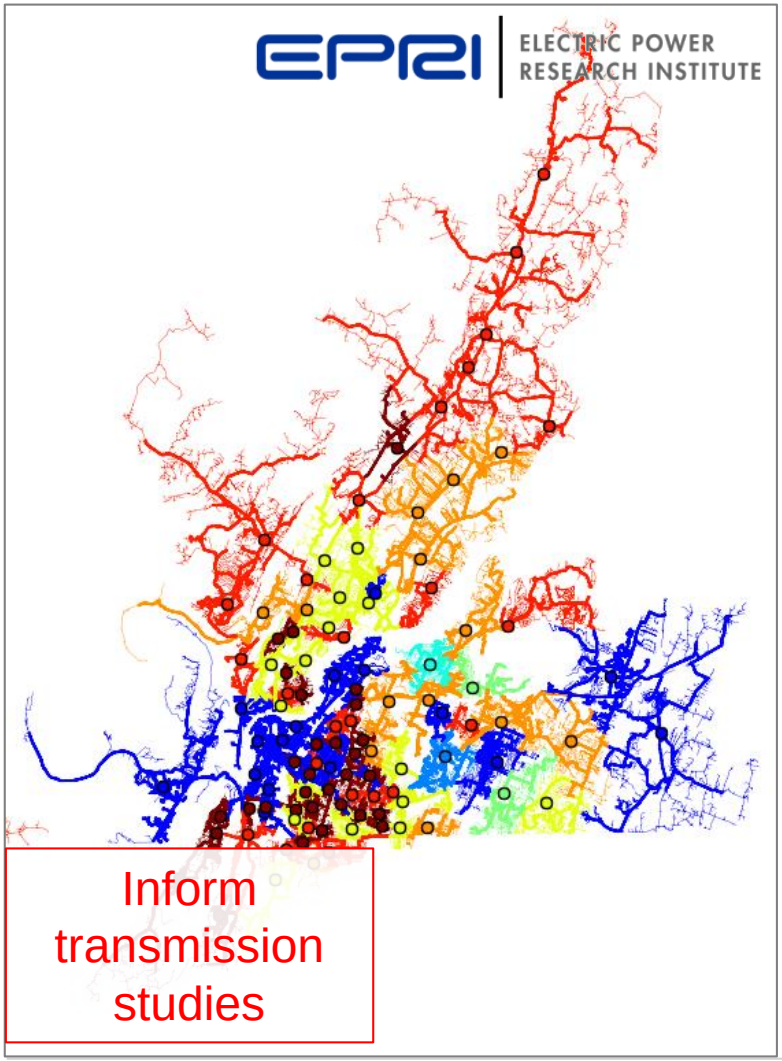
Power System Criteria Evaluation



Distribution System-Wide Hosting Capacity

Sample Results from One Utility Application

System Hosting Capacity
(~ 300 distribution feeders)



Substation Marker

***Hosting Capacity**

lower

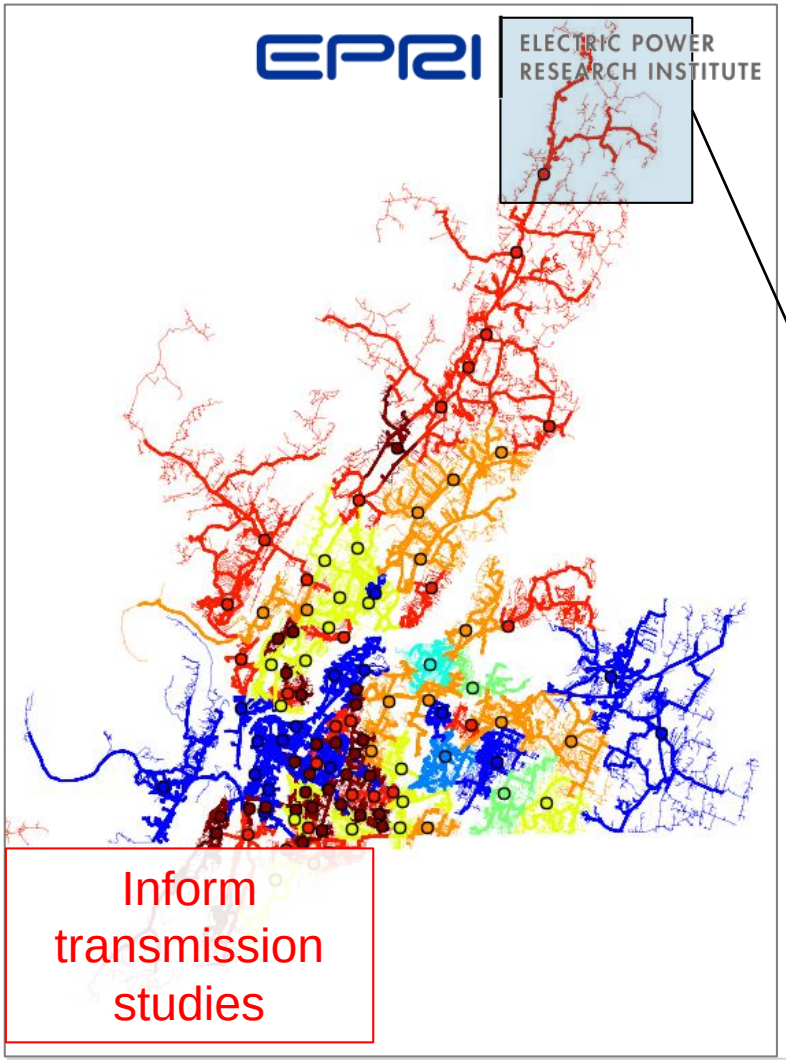
higher

**Initial analysis results from TVA/ EPB study, results not finalized*

Distribution System-Wide Hosting Capacity

Sample Results from One Utility Application

System Hosting Capacity
(~ 300 distribution feeders)



Inform transmission studies

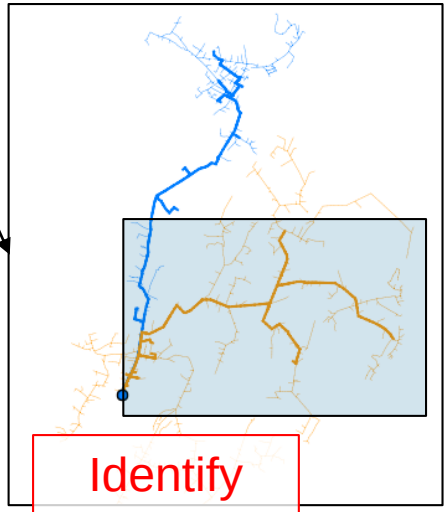
Substation Marker

***Hosting Capacity**

lower

higher

Substation-level Hosting Capacity



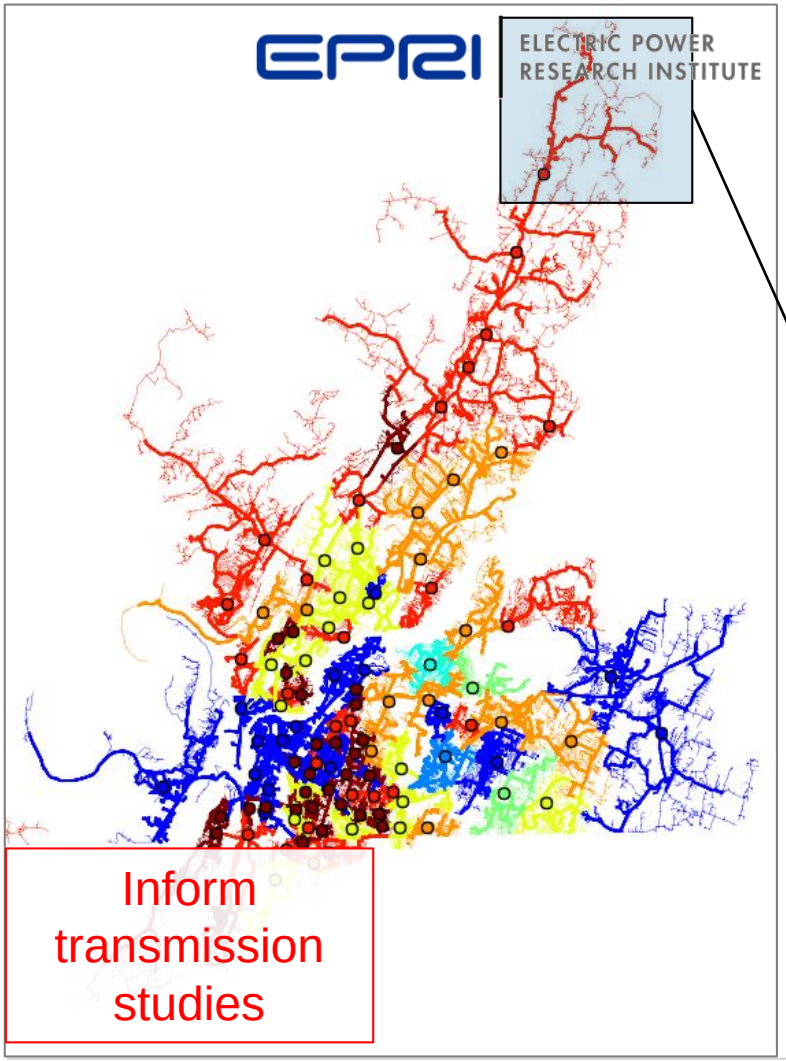
Identify feeders

**Initial analysis results from TVA/ EPB study, results not finalized*

Distribution System-Wide Hosting Capacity

Sample Results from One Utility Application

System Hosting Capacity
(~ 300 distribution feeders)



Inform transmission studies

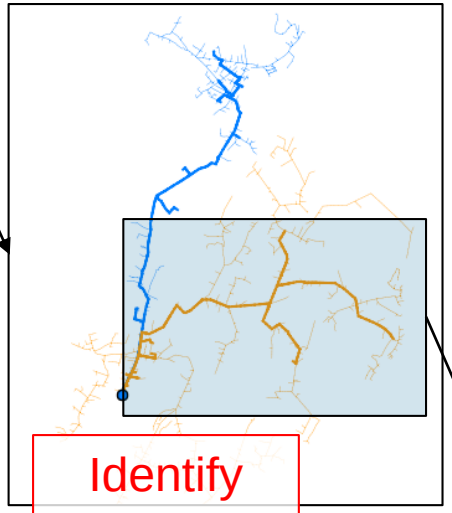
Substation Marker

***Hosting Capacity**

lower

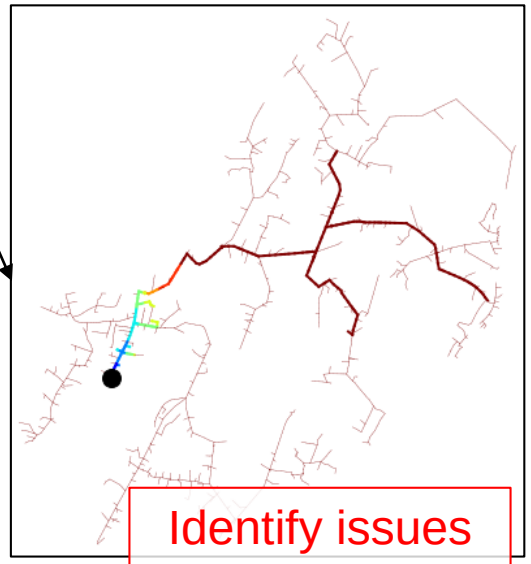
higher

Substation-level Hosting Capacity



Identify feeders

Feeder-level Hosting Capacity



Identify issues and locations

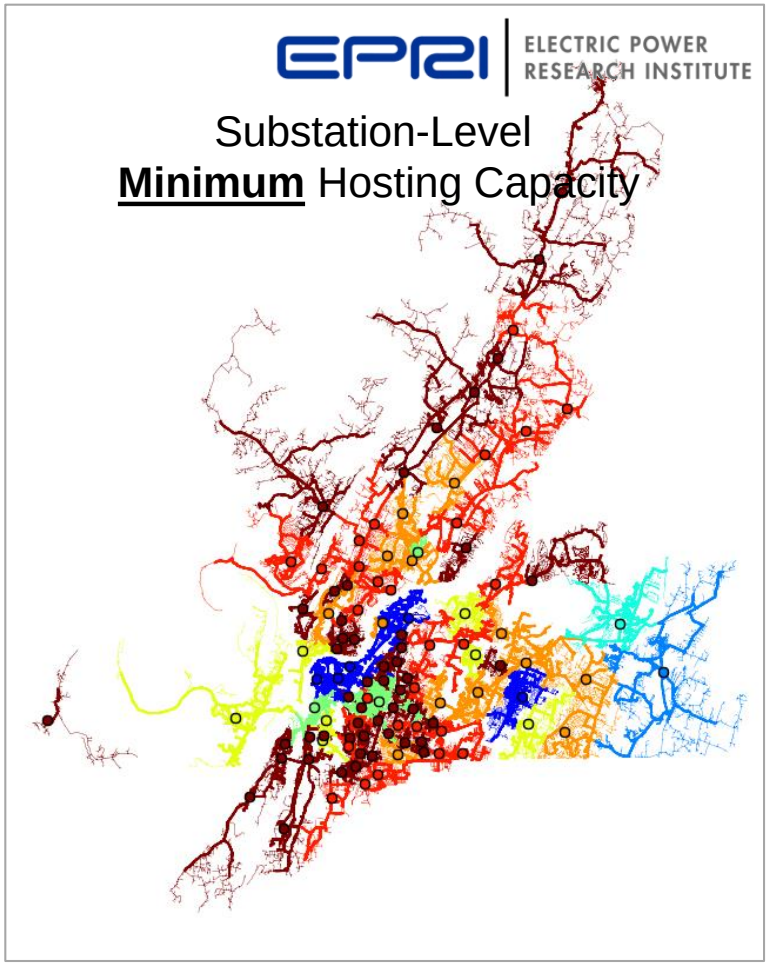
**Initial analysis results from TVA/ EPB study, results not finalized*

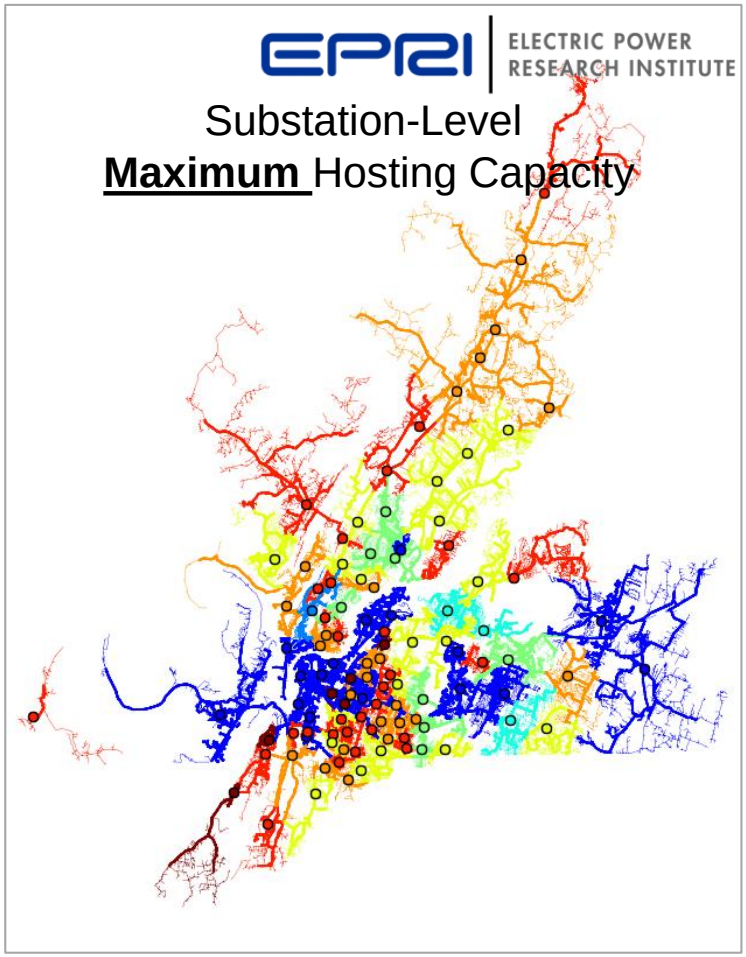
Graphic Visualization of System-Wide Results

Hosting Capacity

lower

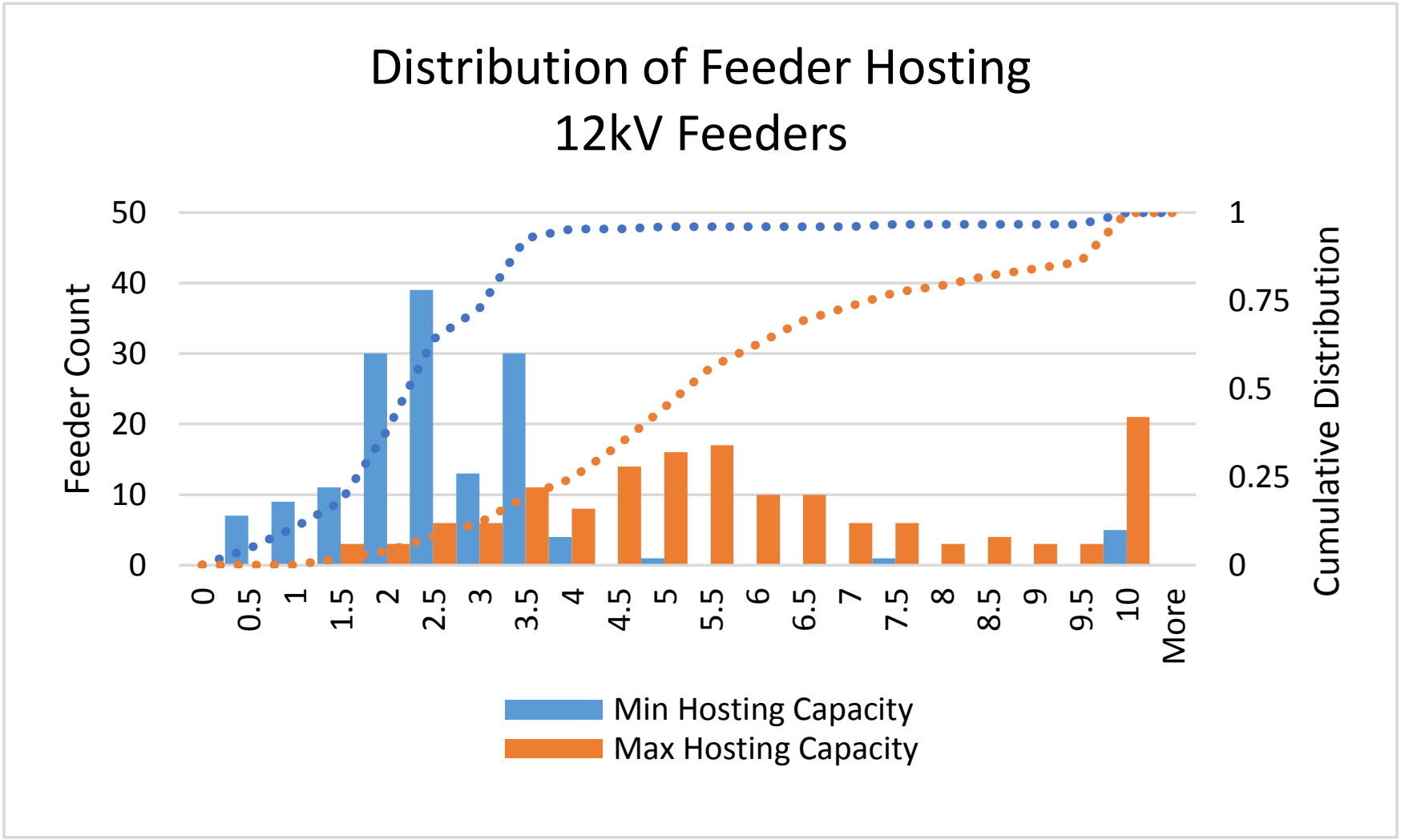
higher





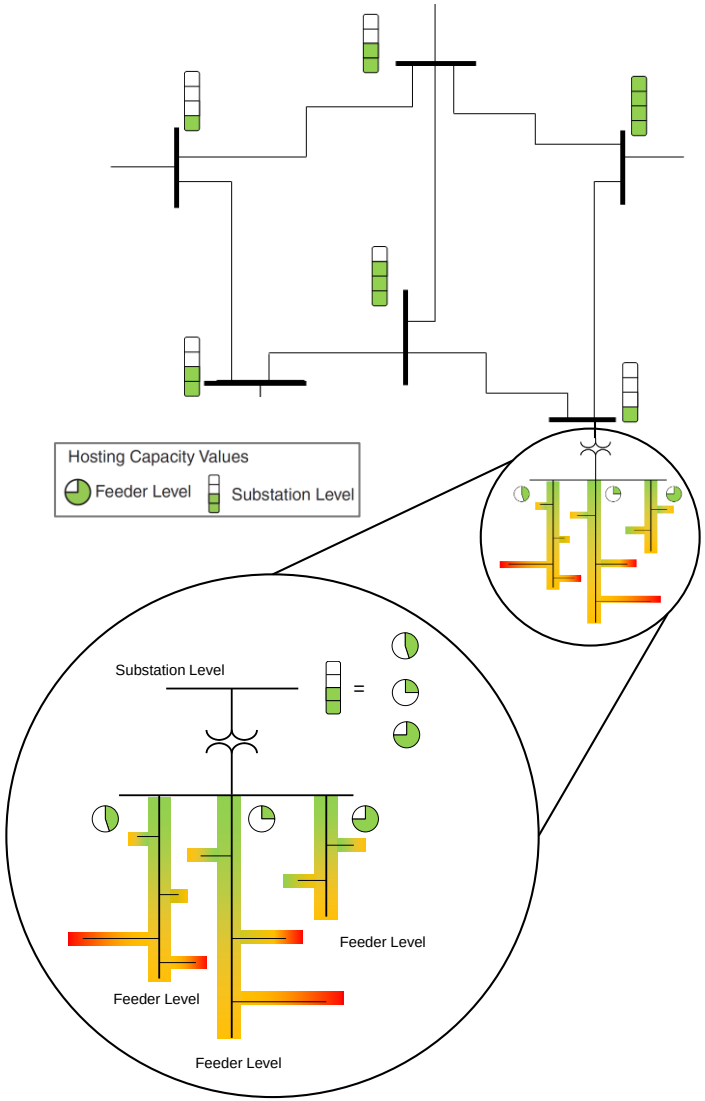
Distribution of Feeder Hosting Capacity Values

Large-Scale Centralized PV



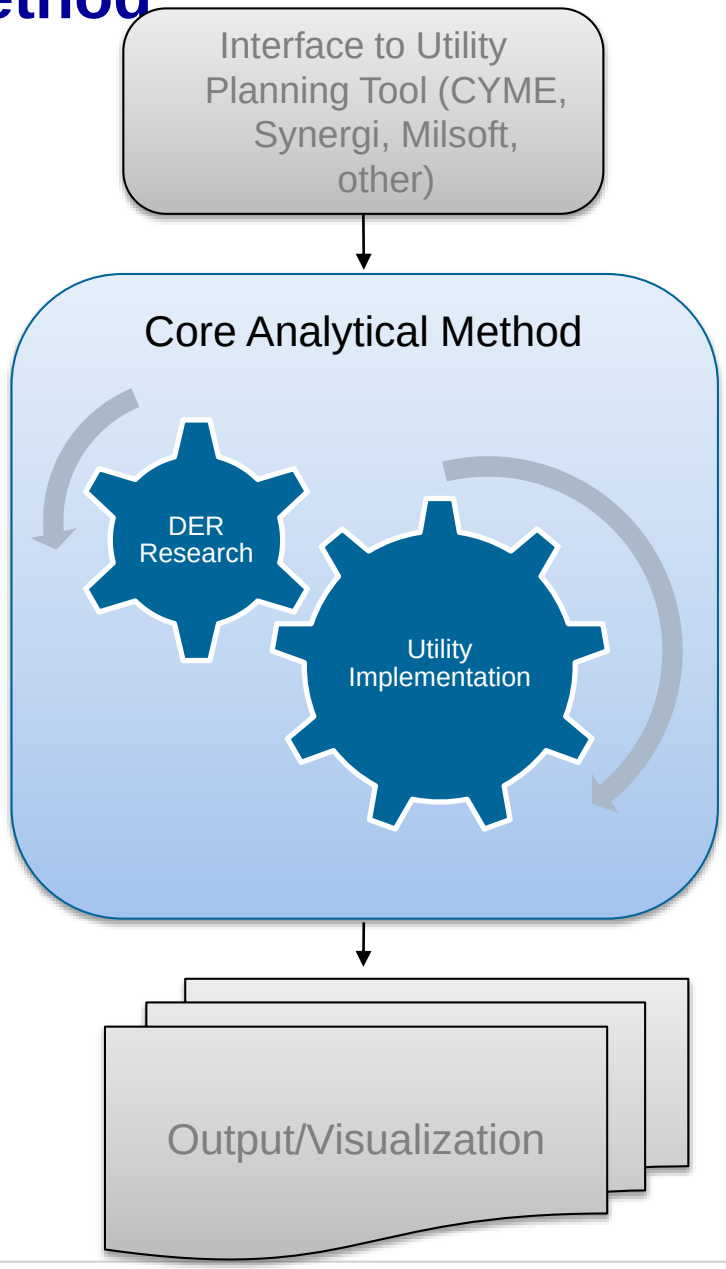
Applications For Streamlined Hosting Capacity Method

- Improving interconnection screening (accuracy and efficiency)
- Identifying optimal locations for locating DER
- Mapping DER impacts across system
- Identifying issues/mitigations needed to accommodate higher penetrations
- Establishing the cost/benefit of DER
- Informing distribution resource plans
- Informing bulk system studies



Advancing the Core Analytical Method
(Streamlined Hosting Capacity Algorithm)

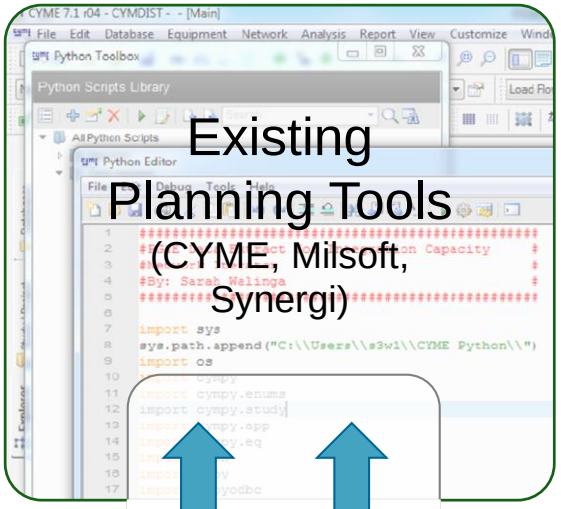
- Implemented separate from DSA platform interface/output
- Further advancements are underway – and will be ongoing thru R&D and utility implementation
- Near-term capabilities to be added
  - Mitigation: accommodating higher than existing hosting capacity
  - DER Value: thermal capacity and energy
  - Smart inverters: guidance for settings and determining higher hosting capacity values
  - Energy storage: constrained and controlled



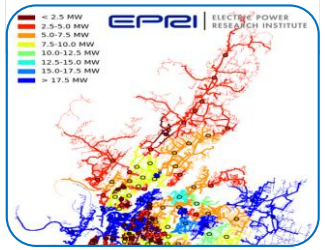
Wrap-Up

- Existing methods aren't sufficient to address today's challenges
- New methods are needed
- Advancing open-source tools is first step (OpenDSS)
- Applications/methods can then be implemented in commercial tools
- Streamlined Hosting Capacity Method Currently Developed in
  - CYME
  - Synergi
  - Milsoft
- Current Applications
  - DOE SUNRISE Project (TVA +Southern Co)
  - EPRI Project (SRP, XCEL, SCE, Central Hudson, HydroOne)
  - > 3000 feeders analyzed

Incorporating EPRI's Hosting Capacity Method into existing utility planning tool



EPRI Streamlined Hosting Module



Together…Shaping the Future of Electricity

References

Detailed Hosting Capacity Method

- Analysis of High-Penetration Solar PV Impacts for Distribution Planning: Stochastic and Time-Series Methods for Determining Feeder Hosting Capacity. EPRI, Palo Alto, CA: 2012. 1026640
- Rylander, M., Smith, J., “Comprehensive Approach for Determining Distribution Network Hosting Capacity for Solar PV”, 2nd International Workshop on Integration of Solar Power Into Power Systems, Lisbon, Portugal, Nov 2012.
- Rylander, M., Smith, J., "Stochastic Approach for Distribution Planning with Distributed Energy Resources", 2012 CIGRE Grid of the Future Symposium, Kansas City, MO, 2012
- Analysis of High-Penetration Solar PV Impacts for Distribution Planning: Stochastic and Time-Series Methods for Determining Feeder Hosting Capacity. EPRI, Palo Alto, CA: 2012. 1026640
- Rylander, M., Smith, J., "Comprehensive Approach for Determining Distribution Network Hosting Capacity for Solar PV", 2nd International Workshop on Integration of Solar Power Into Distribution Systems, 12-13 November, 2012
- Rylander, M., Smith, J., Lewis, D., Steffel, S., "Voltage Impacts from Distributed Photovoltaics on Two Distribution Feeders", IEEE PES, Vancouver, Canada, 2013
- *Distributed Photovoltaic Feeder Analysis: Preliminary Findings from Hosting Capacity Analysis of 18 Distribution Feeders.* EPRI, Palo Alto, CA: 2013. 3002001245.
- *Alternatives to the 15% Rule: Modeling and Hosting Capacity Analysis of 16 Feeders.* EPRI, Palo Alto, CA: 2015. 3002005812.

Streamlined Hosting Capacity Method

- *A New Method for Characterizing Distribution System Hosting Capacity for Distributed Energy Resources: A Streamlined Approach for Solar Photovoltaics.* EPRI, Palo Alto, CA: 2014. 3002003278.
- Rylander, M., Smith, J., Sunderman, W., “Streamlined Method For Determining Distribution System Hosting Capacity”, 23rd International Conference on Electricity Distribution, CIRED, Lyon, France, 2015
- Rylander, M., Smith, J., Sunderman, W., “Streamlined Method For Determining Distribution System Hosting Capacity”, Rural Electric Power Conference, Asheville, NC, 2015 (accepted for IAS Transactions)
- *Distribution Feeder Hosting Capacity: What Matters When Planning for DER*?. EPRI, Palo Alto, CA: 2015. 3002004777

General

- The Integrated Grid: A Benefit-Cost Framework,” EPRI, Palo Alto, CA. 3002004878, 2015.
- Distribution Feeder Hosting Capacity: What Matters When Planning for DER?. EPRI, Palo Alto, CA: 2015. 3002004777
- Smith, J., Rylander, M., Rogers, L., Dugan, R., “It’s All in the Plans: Maximizing the Benefits and Minimizing the Impacts of DERs in an Integrated Grid”, Power and Energy Magazine, March/April 2015.